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(54) **METHOD FOR ACTUATING A TACTILE INTERFACE LAYER**

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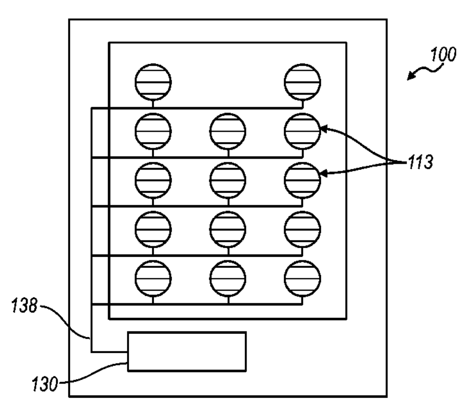
(57) **ABSTRACT**

A method for actuating a tactile interface layer of a device that defines a surface with a deformable region, comprising the steps of deforming a deformable region of the surface into a formation tactilely distinguishable from the surface, detecting a force from the user on a deformed deformable region, interpreting the force as a command for the deformable region, and manipulating the deformable region of the surface based on the command.

21 Claims, 5 Drawing Sheets



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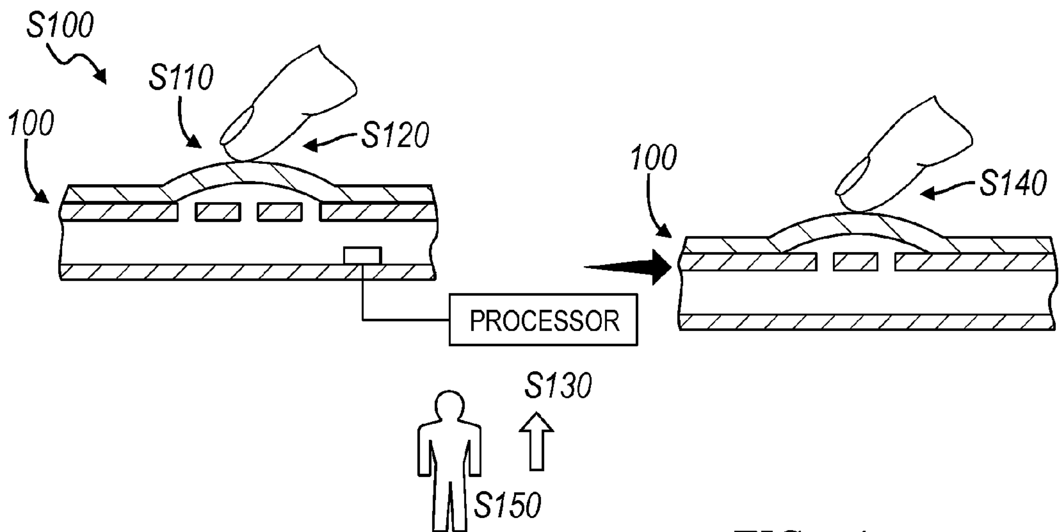

S100
S110
100
S120
S140
100
PROCESSOR
S130
S150

FIG. 1

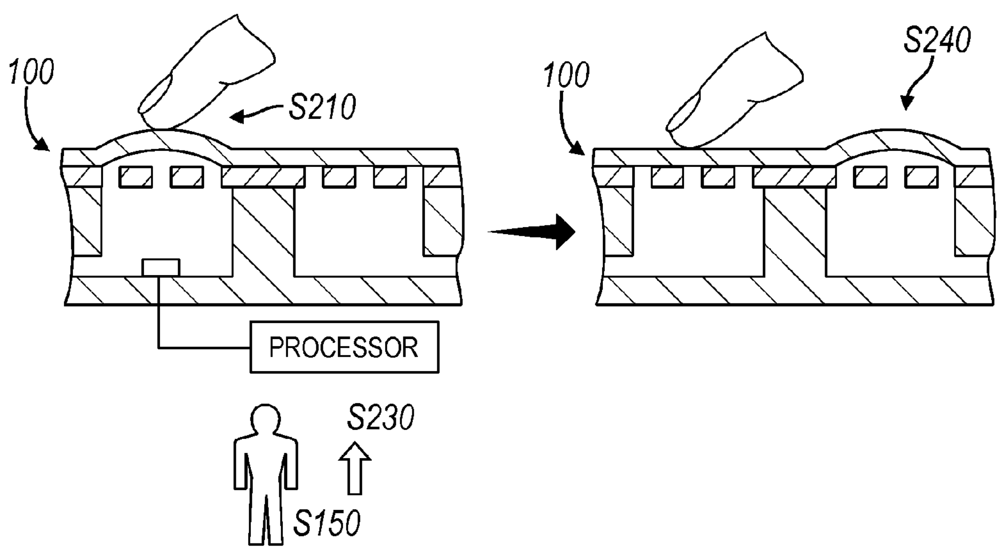
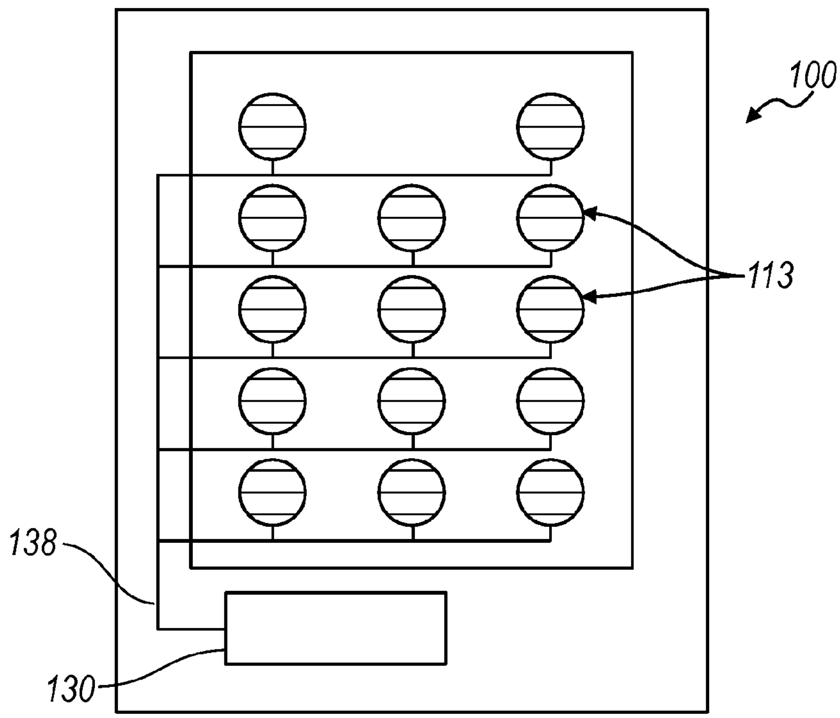
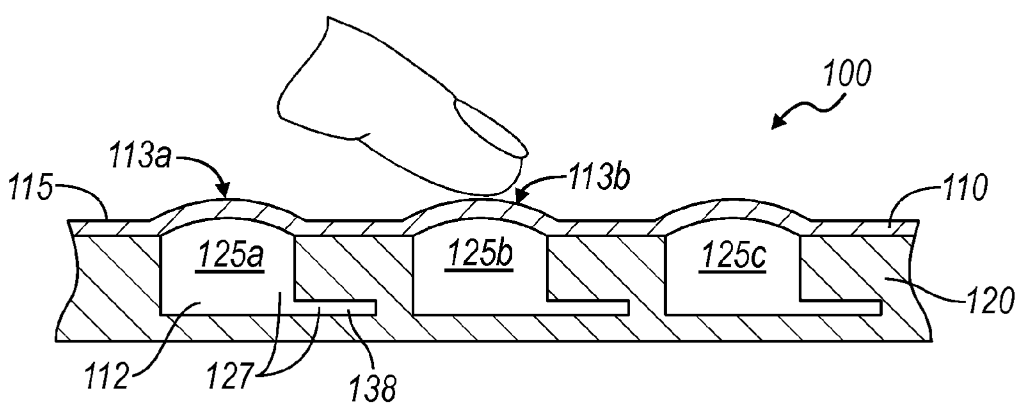

100
S210
100
S240
PROCESSOR
S230
S150

FIG. 2



100
113
138
130

FIG. 3



100
113a
113b
115
110
125a
125b
125c
120
112
127
138

FIG. 4

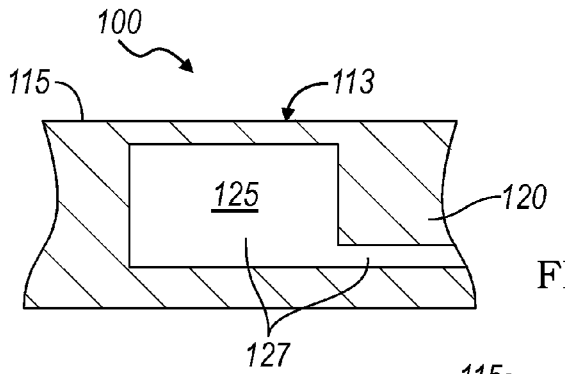


FIG. 5A

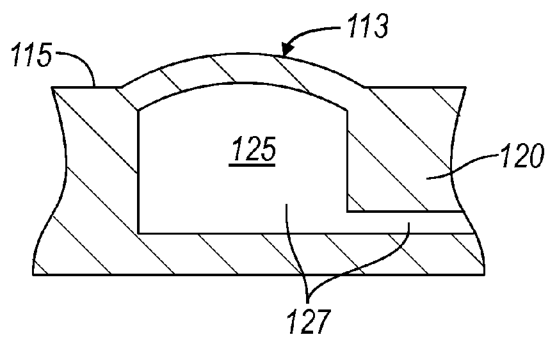


FIG. 5B

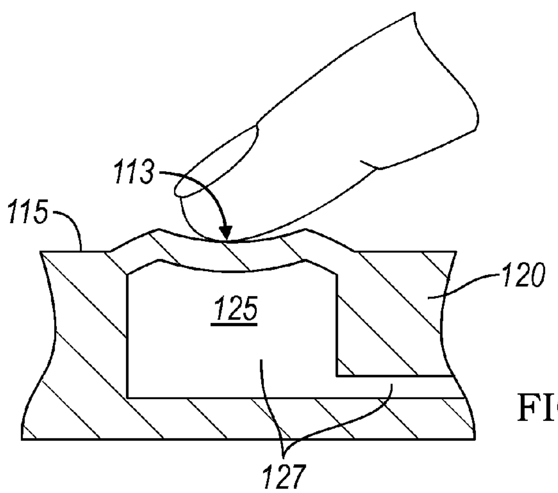


FIG. 5C

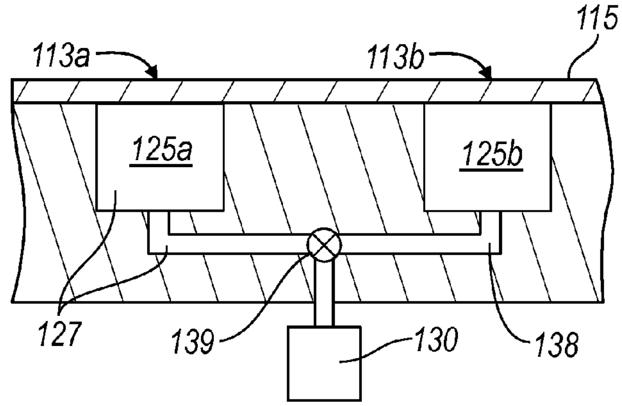


FIG. 6

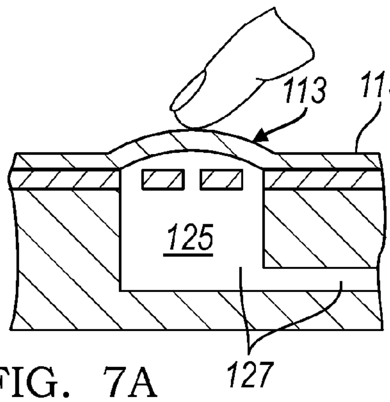


FIG. 7A

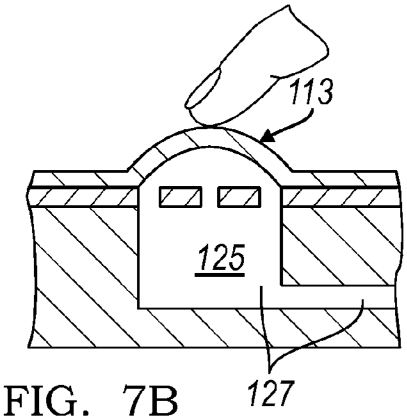


FIG. 7B

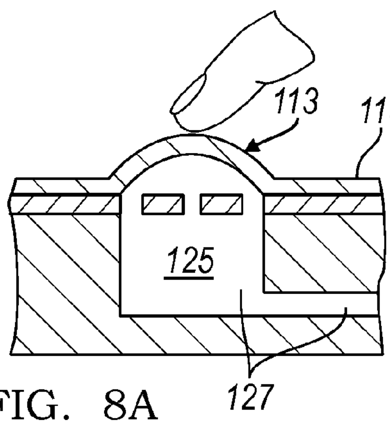


FIG. 8A

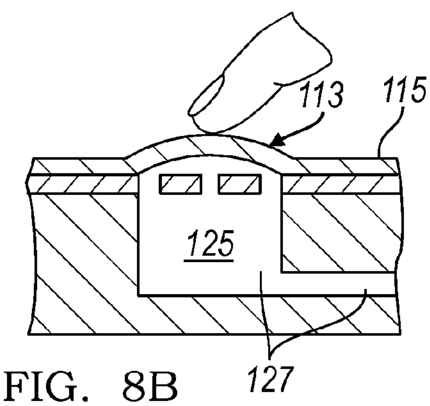


FIG. 8B

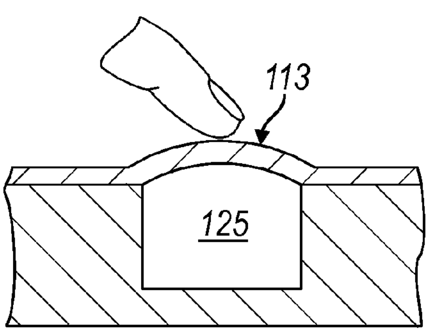


FIG. 9A

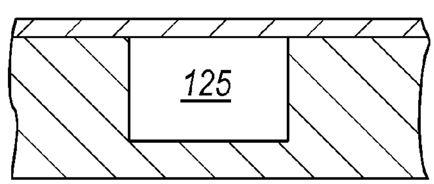


FIG. 9B

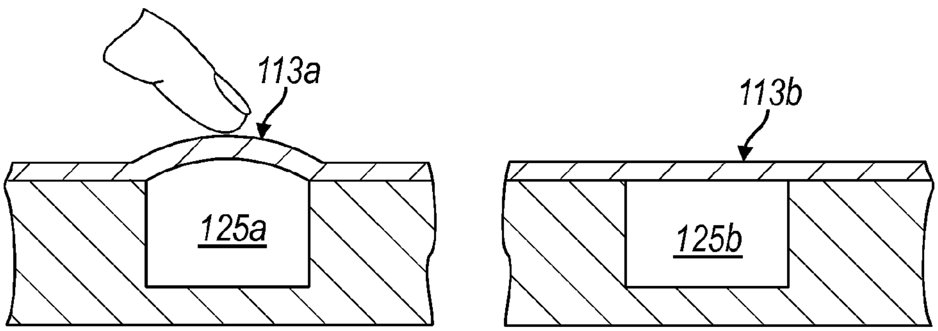


FIG. 10A

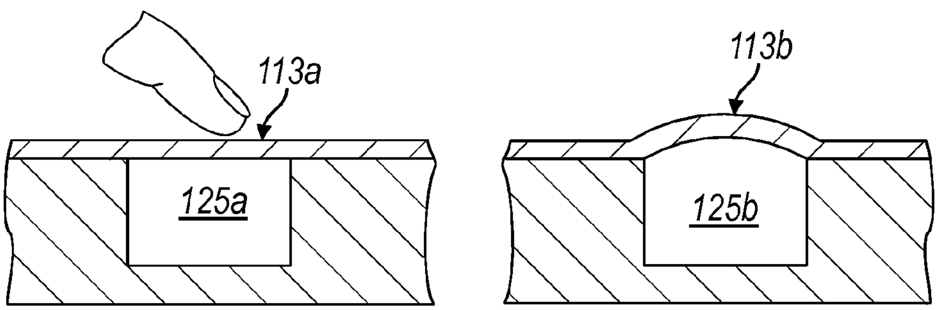


FIG. 10B

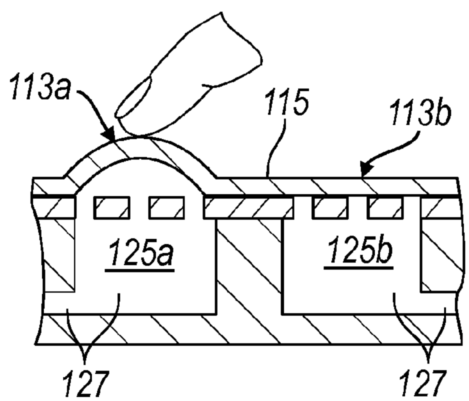


FIG. 11A

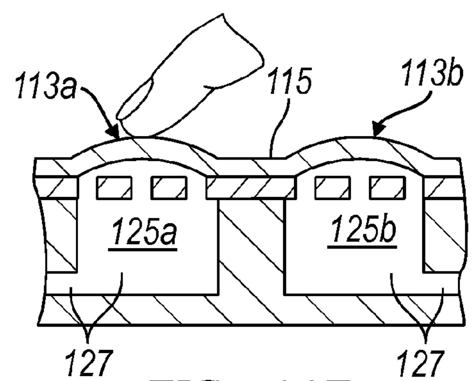


FIG. 11B

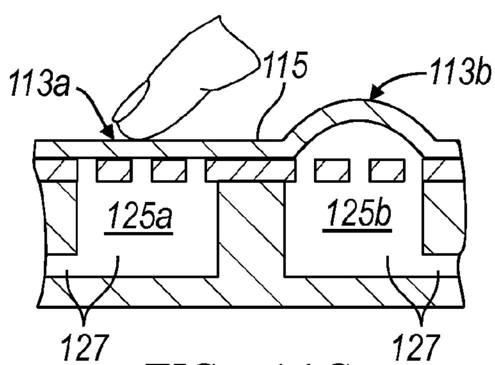


FIG. 11C

METHOD FOR ACTUATING A TACTILE INTERFACE LAYER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/090,217, filed on 19 Apr. 2011, which claims the benefit of U.S. Provisional Application No. 61/325,772, filed on 19 Apr. 2010, which are both incorporated in their entireties by this reference.

This application is related to U.S. patent application Ser. No. 11/969,848 filed on 4 Jan. 2008, U.S. patent application Ser. No. 12/319,334 filed on 5 Jan. 2009, U.S. patent application Ser. No. 12/497,622 filed on 3 Jul. 2009, which are all incorporated in their entirety by this reference.

TECHNICAL FIELD

This invention relates generally to tactile user interfaces, and more specifically to a new and useful method for interpreting gestures as commands for a tactile interface layer with a deformable region.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a schematic representation of the method of the first preferred embodiment.

FIG. **2** is a schematic representation of the method of the second preferred embodiment.

FIG. **3** is a top view of a variation of the tactile interface layer.

FIG. **4** is a cross sectional view of a variation of the tactile interface layer.

FIGS. **5**A-**5**C are cross-sectional views illustrating the operation of a deformable region of a tactile interface layer.

FIG. **6** is a cross sectional view of a variation of the tactile interface layer with a valve.

FIGS. **7**A-**9**B are schematic representations of a first, second, and third variation in the manipulation of the firmness of the deformed particular region in the first preferred embodiment.

FIGS. **10**A-**11**C are schematic representations of a first and second variation in the manipulation of a first and second particular region in the second preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description of the preferred embodiments of the invention is not intended to limit the invention to these preferred embodiments, but rather to enable any person skilled in the art to make and use this invention.

As shown in FIGS. **1** and **2**, the method S**100** for actuating a tactile interface layer **100** of a device that defines a surface with a deformable region of the preferred embodiments includes deforming a deformable region of the surface into a formation tactilely distinguishable from the surface Step S**110** and S**210**, detecting a force from the user on the deformed region of the surface Steps S**120** and S**220**, interpreting a command for the deformable region of the surface based on the detected force, and manipulating the deformable regions based on the command. In the first preferred embodiment, as shown in FIG. **1**, the step of interpreting a command includes interpreting the force on the deformable region as a command for the firmness of the deformed deformable region Step S**130** and the step of manipulating the deformable regions based on the command includes manipulating the firmness of the deformable region of the surface based on the command Step S**140**. In the second preferred embodiment, as shown in FIG. **2**, the tactile interface layer includes a first and second deformable region and the step of interpreting a command includes interpreting the force on the deformed deformable region as a command to undeform the first deformable region and to deform the second deformable region into formation tactilely distinguishable from the surface Step S**230** and the step of manipulating the deformable regions based on the command includes manipulating the first and second deformable regions based on the command Step S**240**. The method S**100** for actuating a tactile interface layer **100** of a device may also include detecting a force from the user on a plurality of deformed deformable regions, which may also include the step of detecting the sequence in which a force is detected on each of the deformed deformable regions. In this variation, the step of interpreting a command may include interpreting a command for at least one deformable region of the surface based on the detected sequence of forces. However, any other suitable type of force detection relative to the deformed deformable regions of the surface may be used.

The method S**100** of the first and second preferred embodiments for actuating a tactile interface layer **100** may also include the step of receiving a user input for a particular interpretation of a force as a command Step S**150**. The step of receiving a user input for a particular interpretation of a force as a command Step S**150** may include receiving a user input from the user of the device, but may alternatively include receiving a user input from a person remote from the device, for example, a third party such as the manufacturer or a second user. However, the user input for a particular interpretation of a force as a command may be received from any other suitable user. The method S**100** is preferably applied to a tactile interface layer **100** that is to be used with an electronic device. More preferably, in an electronic device that benefits from an adaptive user interface. The electronic device may or may not include a display and/or a touch sensor, for example, an automotive console, a steering wheel, a desktop computer, a laptop computer, a tablet computer, a television, a radio, a desk phone, a mobile phone, a PDA, a personal navigation device, a personal media player, a camera, a watch, a remote control, a mouse, a trackpad, or a keyboard. The tactile interface layer **100** may, however, be used as the user interface for any suitable device that interfaces with a user in a tactile and/or visual manner. The tactile interface layer **100** is preferably integrated with the device, for example, in the variation wherein the tactile interface layer **100** includes a sensor **140**, the tactile interface layer **100** is preferably assembled into the device and presented to the user as one unit. Alternatively, the tactile interface layer **100** may function as an accessory to a device, the user may be presented the tactile interface layer **100** and the device as two separate units wherein, when coupled to each other, the tactile interface layer **100** functions to provide tactile guidance to the user and/or to receive user inputs. However, the method S**100** may be applied to any other suitable arrangement of the tactile interface layer **100**.

The method S**100** of the preferred embodiments is preferably applied to any suitable tactile interface layer that includes deformable regions. In particular, as shown in FIGS. **3-5**, the method S**100** of the preferred embodiments may be applied to the user interface system as described in U.S. application Ser. Nos. 11/969,848, 12/319,334, and

12/497,622. The tactile interface layer **100** of this variation preferably includes a layer **110** that defines a surface **115**, a substrate **120** that supports the layer **110** and at least partially defines a fluid vessel **127** that includes a volume of fluid **112**, and a displacement device **130** coupled to the fluid vessel **127** that manipulates the volume of fluid **112** to expand and/or contract at least a portion of the fluid vessel **127**, thereby deforming a particular region **113** of the surface **115**. The substrate **115** may also function to substantially prevent the layer **110** from inwardly deforming, for example, into the fluid vessel **127**. In this variation of the tactile interface layer **100**, the steps of manipulating the deformable region of the surface based on the command Steps **S140** and **S240** preferably include manipulating the fluid within the fluid vessel **127**. In particular, the displacement device **130** is preferably actuated to manipulate the fluid within the fluid vessel **127** to deform a particular region **113** of the surface. The fluid vessel **127** preferably includes a cavity **125** and the displacement device **130** preferably influences the volume of fluid **112** within the cavity **125** to expand and retract the cavity **125**. However, any other suitable method of manipulating the fluid **112** may be used.

The fluid vessel **127** may alternatively be a channel **138** or a combination of a channel **138** and a cavity **125**, as shown in FIG. **4**. The fluid vessel **127** may also include a second cavity **125*b*** in addition to a first cavity **125*a***. When the second cavity **125*b*** is expanded, a second particular region **113** on the surface **115** is preferably deformed. The displacement device **130** preferably influences the volume of fluid **112** within the second cavity **125*b*** independently of the first cavity **125*a***. As shown in FIG. **6**, the tactile interface layer of this variation may include a valve **139** that functions to direct fluid within the tactile interface layer **100**. In this variation, the step of manipulating the fluid within the fluid vessel **127** may include actuating the valve **139** to direct fluid within the tactile interface layer **100**. Alternatively, the user interface enhancement system **100** may include a second displacement device **130** that functions to influence the volume of fluid **112** within the second cavity **125*b*** to expand and retract the second cavity **125*b***, thereby deforming a second particular region **113*b*** of the surface. The second cavity **125*b*** is preferably similar or identical to the cavity **125**, but may alternatively be any other suitable kind of cavity. The following examples may be described as expanding a fluid vessel **127** that includes a cavity **125** and a channel **138**, but the fluid vessel **127** may be any other suitable combination of combination of cavity **125** and/or channel **138**. However, any other suitable type of tactile interface layer **100** may be used.

The tactile interface layer **100** preferably functions to provide tactile guidance to the user when using a device that tactile interface layer **100** to. As shown in FIG. **5**, the surface **115** of the tactile interface layer **100** preferably remains flat until tactile guidance is to be provided to the user at the location of the particular region **113**. In the variation of the tactile interface layer **100** as described above, the displacement device **130** then preferably expands the cavity **125** (or any other suitable portion of the fluid vessel **127**) to expand the particular region **113** outward, forming a deformation that may be felt by a user (referenced throughout this document as a "tactilely distinguishable formation"), and providing tactile guidance for the user. The expanded particular region **113** preferably also provides tactile feedback to the user when he or she applies force onto the particular region **113** to provide input. This tactile feedback may be the result of Newton's third law, whenever a first body (the user's finger) exerts a force on a second body (the surface **115**), the second body exerts an equal and opposite force on the first body, or, in other words, a passive tactile response. Alternatively, the displacement device **130** may retract the cavity **125** to deform the particular region **113** inward. However, any other suitable method of deforming a particular region **113** of the tactile interface layer **100** may be used.

The tactile interface layer **100** preferably includes a sensor that functions to detect the force applied to the deformed particular region **113** by the user. The force may be a force that substantially inwardly deforms the deformed particular region **113** of the surface, but may alternatively be a force that does not substantially inwardly deform the deformed particular region **113**. However, any other suitable type of force may be detected. At a sensor coupled to the tactile interface layer, an input may be detected that is applied at the deformable region in the expanded setting. Substantially simultaneously, an increase in pressure of fluid in the fluid vessel may be detected. For example, in the variation of the tactile layer as described above, the sensor may be a pressure sensor that functions to detect the increased pressure within the fluid **112** that results from an inward deformation of the deformed particular region **113**. Alternatively, the sensor may be a capacitive sensor that detects the presence of a finger on the deformed particular region **113**. In this variation, the presence of a force is deduced from the detected presence of the finger of the user. Alternatively, the sensor may be a sensor included in the device to which the tactile interface layer **100** is applied to, for example, the device may include a touch sensitive display onto which the tactile interface layer **100** is overlaid. The force of the user may be detected using the sensing capabilities of the touch sensitive display. However, any other suitable force detection may be used.

Similarly, the tactile interface layer **100** preferably includes a processor that functions to interpret the detected gesture as a command. The processor may include a storage device that functions to store a plurality of force types (for example, the magnitude of the force or the duration of the applied force) and command associations and/or user preferences for interpretations of the force as commands. The processor may be any suitable type of processor and the storage device may be any suitable type of storage device, for example, a flash memory device, a hard drive, or any other suitable type. The processor and/or storage device may alternatively be a processor and/or storage device included into the device that the tactile interface layer **100** is applied to. However, any other suitable arrangement of the processor and/or storage device may be used.

As shown in FIGS. **7-9**, in the first preferred embodiment of the method **S100**, the force on the deformed particular region is interpreted as a command for the firmness of the deformed particular region Step **S130** and the firmness of the deformed particular region is manipulated based on the command Step **S140**. The manipulation of the firmness of the deformed particular region may alternatively be thought of as manipulating the degree of deformation of the deformed particular region. For example, a fully deformed particular region **113** is of the highest firmness degree while a medium deformed particular region **113** is of a medium firmness degree. In the variation of the tactile interface layer as described above, manipulating the deformed particular region based on the command to change the firmness of the deformed particular region preferably includes manipulating the volume of fluid **112** within the fluid vessel **127**. As the pressure within the volume of fluid **112** is increased, the firmness of the resulting deformed particular region **113** will also increase. Similarly, as the pressure within the volume of fluid **112** is decreased, the firmness of the resulting deformed particular region **113** will also decrease. As shown in FIGS. **7** and **8**, as the pressure of the volume of fluid **112** is changed, size of the deformed particular region **113** may change due to the elasticity of the layer no. In this variation, a change in firmness of the deformed particular region **113** may also be thought of as a change in the size and/or height of the deformed particular region **113**. For example, as shown in FIG. **7**, the pressure of the volume of fluid **112** corresponding to the deformable region is increased and the resulting deformed particular region **113** is both stiffer and taller than the original deformed particular region **113**. In a second example as shown in FIG. **8**, the pressure of the volume of fluid **112** is decreased and the resulting deformed particular region **113** is both less stiff and less tall than the original deformed particular region **113**. In a third example, the pressure of the volume of fluid **112** corresponding to the deformable region is increased to increase the surface area of the deformed particular region **113**. In this variation, the height of the deformed particular region **113** may change, but it may alternatively remain the same. However, any other suitable combination of firmness and size of the deformed particular region resulting from the manipulation of the firmness of the deformed particular region **113** in Step S**140** may be used.

In a variation of the first preferred embodiment, as shown in FIG. **9**, the step of manipulating the deformable region may include undeforming the deformed particular region **113** such that the particular region of the surface **113** is no longer deformed. In other words, the firmness and/or the height of the deformed particular region is "removed" or decreased to zero. This may be a useful tactile experience where the user is to select items from a list, for example, a check box or a "YES/NO" selection box to tactilely indicate to the user when a certain selection has already been made. However, any other suitable application of this variation of the first preferred embodiment may be used.

As shown in FIGS. **10-11**, in the second preferred embodiment of the method S**100**, the tactile interface layer preferably includes a first and a second particular region **113***a* and **113***b*, and the force on the first deformed particular region **113***a* is interpreted as a command to undeform the first particular region **113***a* and to deform the second particular region **113***b* Step S**230**, and the first and second particular regions **113***a* and **113***b* are manipulated based on the command Step S**240**. The first and second particular regions **113***a* and **113***b* may be substantially proximal to each other, for example, along the same face of the device. Alternatively, the first and second particular regions **113***a* and **113***b* may be substantially distal fro each other, for example, the first particular region **113***a* may be on a first face of the device and the second particular region **113***b* may be on a second face of the device. In this variation, the first face of the device may include a display and the second face of the device may not include a display. However, any other suitable arrangement of the first and second particular regions **113***a* and **113***b* may be used. The force may alternatively be interpreted as a command to further deform the first particular region **113***a* and to undeform the second particular region **113***b*. However, any other suitable combination of deformation and undeformation of the first and second particular regions **113***a* and **113***b* may be used. The interpreted command may be to fully undeform the first particular region **113***a* and to fully deform the second particular region **113***b*, which may provide the user with a "rocker switch" type of experience, as shown in FIG. **10**. In this variation, both the first and second particular regions **113***a* and **113***b* may be located on the same device, for example, to provide a tactile experience where the user is to toggle between two selections for a particular, for example, "Audio ON" and "Audio OFF" to toggle a location within a game, for example, selecting tiles within the popular Minesweeper game. Alternatively, the second particular region **113***b* may be located on a second tactile interface layer **100** that is applied to a second device, where the second device is linked to the first device, for example, through the Internet, through a WiFi connection, through a Bluetooth connection, or any other suitable connection. Control of the second tactile interface layer **100** is may be independent of the control of the first user interface **100**; for example, the second particular region **113***b* may be deformed independently of the first particular region **113***a*. Alternatively, control of the second tactile interface layer may be linked to the control of the first tactile interface layer **100**. This may be a useful tactile experience where the first device and the second device are transmitting tactile communication, for example, when a user using the first device creates a pattern by undeforming a pattern of deformed particular regions **113** and another user using the second device "sees" the pattern that the first user is creating deformable particular regions **113** corresponding to the undeformed particular regions **113** on the first device are deformed. This type of feature may be used in a gaming device or gaming application where a first player uses tactile communication with a second player. However, any other suitable application of a "rocker switch" type active response may be used.

Alternatively, the interpreted command may be to undeform the first particular region **113***a* to a particular degree and to deform the second particular region **113***b* to a particular degree, as shown in FIGURE ii. The degree to which to undeform and deform the first and second particular regions **113***a* and **113***b* may be determined based on the detected attributes of the force. In a first example, the magnitude of the force may determine the particular degrees. In the variation where the tactile interface layer includes fluid **112** and a pressure sensor, the pressure increase within the fluid **112** may be used to determine the magnitude of the force. However, the magnitude of the force may be determined using any other suitable method, for example, the applied force may displace the volume of fluid **112** from one location within the fluid vessel **127** to another. The magnitude of the force may be determined by measuring the amount of fluid displacement. In a second example, the duration of the applied force may be used to determine the particular degrees. In the variation where the tactile interface layer includes a sensor that is a capacitive sensor, the presence of the finger of the user may be detected and the period of time for which the presence of the finger is detected may be used to determine the particular degrees. In a third example, the rate at which the force is applied may be used to determine the particular degrees. As described above, the volume of fluid **112** displaced by the applied force may be measured. In this variation, the rate at which the force is applied may be determined by detecting the rate at which the volume of fluid **112** is displaced. However, the particular degrees to which to undeform and deform the first and second particular regions **113***a* and **113***b* may be interpreted from the detected force using any other suitable method.

Additionally, the particular degrees to undeform and deform the first and second particular regions **113***a* and **113***b* may be percentages of the full deformation of each of the particular regions **113***a* and **113***b*, where the sum of the percentage of deformation of the first and second particular regions **113**a and **113**b is 100%. In other words, the command may include undeforming the first particular region **113**a to 25% of full deformation and deforming the second particular region **113**b to 75% of the full deformation. This may provide a tactile experience to the user that is similar to pushing a mass from one location to another location, where there is a conservation of mass. Alternatively, the percentages may have a sum of greater than or less than 100%. For example, the command may include deforming each of the first and second particular regions **113**a and **113**b to 60% of full deformation. However, any other suitable command for the undeformation and deformation of the first and second particular regions **113**a and **113**b may be interpreted.

In the variation of the tactile interface layer **100** as described above, the fluid vessel **127** includes a first cavity **125**a that corresponds to the first particular region **113**a and a second cavity **125**b that corresponds to the second particular region **113**b. The displacement device **130** is preferably actuated to expand the second cavity **125**b and retract the first cavity **125**a. Retraction of the first cavity **125**a (or the undeformation of the first particular region **113**a) and the expansion of the second cavity **125**b (or the deformation of the second particular region **113**b) preferably happen substantially concurrently, as shown in FIG. **10**. In this variation, when the force and command are interpreted on the deformed first particular region, as shown in FIGURE boa, the volume of fluid within the first cavity **125**a is decreased while the volume of fluid within the second cavity **125**b is increased, as shown in FIG. **10**b. A volume of fluid **112** may be transferred between the first and second cavities **125**a and **125**b by the displacement device **130**, but the displacement device **130** may alternatively displace any other suitable volume of fluid **112** from and to the first and second cavities **125**a and **125**b. For example, the displacement device **130** may displace a volume of fluid towards the first and second cavities **125**a and **125**b through the valve **139**, and the valve **139** directs a first portion of the fluid towards the first cavity **125**a and a second portion of the fluid towards the second cavity **125**b.

As described in the first preferred embodiment, a change in the volume of fluid within the first and second cavities **125**a and **125**b may also be thought of as a change in the firmness of the corresponding deformed particular region **113**a and **113**b, respectively. In a variation of the second preferred embodiment, the undeformation and deformation of the first and second particular regions **113**a and **113**b may alternatively be thought of as a decrease in firmness of the first particular region **113**a and an increase in firmness of the second particular region **113**b. An exemplary usage of this variation of the second preferred embodiment may be in a user interface that includes two buttons for increasing and decreasing a particular feature of the device, for example, the volume of sound output. The deformed first particular region **113**a may represent the "increase volume" button and the second particular region **113**b may represent the "decrease volume" button. As a force is detected on the first particular region **113**a, the firmness of the first particular region **113**a may be increased and the firmness of a second particular region **113** corresponding to a "decrease volume" button decreases, representing the shift towards the higher range along the range of available volume outputs. However, any other suitable application of this variation may be used.

In the method S**100** of the first and second preferred embodiments, the interpretation of the force detected on the deformed deformable region as a command may be adjusted based on the state of the deformed deformable region. For example, if a force is detected when the deformed deformable region is not fully deformed, the command may be to increase the firmness and if a force is detected when the deformed deformable region is fully deformed, the interpreted command may be to decrease the firmness. In a second example, the interpretation of a command when a force is detected as a deformable region is being expanded may be different from when a force is detected as a deformable region is being undeformed. However, any other suitable interpretation of the force as a command based on the state of the deformed deformable region may be used.

While the interpretation of a force detected on a deformed particular region **113** as a command is preferably one of the variations described above, the interpretation may alternatively be a combination of the variations described above or any other suitable combination of gestures and commands, for example, a force may be detected on an undeformed deformable region and then interpreted as a command for the deformable region. However, any other suitable type of force detection and force interpretation may be used.

As a person skilled in the art will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred embodiments of the invention without departing from the scope of this invention defined in the following claims.

We claim:

1. A method for actuating a tactile interface layer coupled to a device, the tactile interface layer comprising a surface and a substrate, the surface defining a deformable region and a second region adjacent the deformable region, the substrate defining a fluid vessel adjacent the deformable region, the method comprising:

displacing fluid into the fluid vessel to transition the deformable region from a retracted setting to an expanded setting tactilely distinguishable from the second region and offset above the second region by a first height;

at a sensor coupled to the tactile interface layer, detecting a user input which applies a force at the deformable region in the expanded setting;

substantially simultaneously, detecting an increase in pressure of fluid in the fluid vessel by a second sensor;

in response to the force, displacing fluid out of the fluid vessel to transition the deformable region from the expanded setting offset above the second region by the first height to a second setting offset above the second region by a second height less than the first height, a change in height between the expanded setting and the second setting proportional to the detected increase in pressure.

2. The method of claim **1**, further comprising, in response to displacing fluid out of the fluid vessel to transition the deformable region from the expanded setting to the second setting, displacing fluid into the fluid vessel to increase pressure within the fluid vessel adjacent the deformable region in the second setting.

3. The method of claim **2**, wherein displacing fluid into the fluid vessel to increase pressure increases resistance to depression of the deformable region toward the substrate.

4. The method of claim **1**, wherein detecting an increase in pressure in the fluid vessel comprises, at a pressure sensor fluidly coupled to the fluid vessel, detecting a change in pressure and, in response to the change in pressure greater than a threshold pressure change, interpreting the change in pressure as a command to displace fluid out of the fluid vessel, the second sensor including the pressure sensor.

5. The method of claim 1, further comprising detecting an initial pressure in the fluid vessel corresponding to the deformable region in the expanded setting; wherein displacing fluid out of the fluid channel comprises displacing a volume of fluid out of the fluid vessel, the volume of fluid substantially proportional to the increase in pressure in the fluid to restore the initial pressure in the fluid vessel.

6. The method of claim 1, wherein displacing fluid out of the fluid vessel comprises displacing fluid out the fluid vessel to transition the deformable region from the expanded setting to the second setting offset above the second region by a second height less than the first height; wherein pressure in the fluid vessel at the second height is greater than pressure in the fluid vessel at the first height.

7. A method for actuating a tactile interface layer coupled to a device, the tactile interface layer comprising a surface and a substrate, the surface defining a deformable region and a second region adjacent the deformable region, the substrate defining a fluid vessel adjacent the deformable region, the method comprising:

displacing fluid into the fluid vessel at a first pressure to transition the deformable region from a retracted setting to an expanded setting tactilely distinguishable from the second region and the deformable region in the retracted setting;

at a sensor coupled to the tactile interface layer, detecting an input which applies a force at the deformable region, the force displacing the deformable region from the expanded setting to a second setting tactilely distinguishable from the expanded setting;

substantially simultaneously, detecting by a second sensor an increase in pressure from the first pressure to a second pressure in the fluid vessel;

with the deformable region in the second setting, displacing fluid into the fluid vessel to change pressure in the fluid vessel from the second pressure to a third pressure in response to the detected increase in pressure, the deformable region stable in the second setting at the third pressure.

8. The method of claim 7, wherein displacing fluid into the fluid vessel comprises increasing pressure in the fluid vessel from the second pressure to the third pressure, greater than the second pressure by a magnitude proportional to the increase in pressure from the first pressure to the second pressure.

9. The method of claim 7, wherein displacing fluid into the fluid vessel comprises displacing fluid into the fluid vessel to increase pressure in the fluid vessel from the second pressure to the third pressure greater than the second pressure by a magnitude proportional to the increase in pressure from the first pressure to the second pressure.

10. The method of claim 9, wherein displacing fluid into the fluid vessel comprises increasing pressure in the fluid vessel from the second pressure to the third pressure greater than the second pressure by a magnitude substantially equal to the increase in pressure from the first pressure to the second pressure.

11. A method for actuating a tactile layer coupled to a computing device and comprising a surface defining a first deformable region, a second deformable region, and a third region adjacent the first deformable region and the second deformable region, the tactile interface layer defining a first fluid vessel adjacent the first deformable region and a second fluid vessel adjacent the second deformable region, the method comprising:

at a sensor, detecting a user input at the first deformable region in an expanded setting, the input applying a force displacing the first deformable region toward the substrate, the first deformable region offset above the third region in the expanded setting, the second deformable region in a retracted setting substantially flush with the first region, the input pressing the deformable region toward the substrate;

substantially simultaneously, detecting by a second sensor a change in pressure in the fluid vessel corresponding to the input;

in response to the change in pressure, displacing a first volume of fluid from the first fluid vessel to transition the deformable region from the expanded setting to a second setting tactilely distinguishable from the expanded setting;

substantially simultaneously, displacing a second volume of fluid into the second fluid vessel to transition the second deformable region from the retracted setting to a third setting tactilely distinguishable from the retracted setting, a ratio of the second volume of fluid to the first volume of fluid proportional to the detected change in pressure.

12. The method of claim 11, further comprising rendering a first graphical icon and a second graphical icon on a display coupled to the tactile layer substrate opposite the surface, the first graphical icon substantially aligned with the first deformable region and second graphical icon substantially aligned with the second deformable region; wherein detecting an input at the first deformable region comprises detecting the input at the first deformable region and defining the input as a selection of the first graphical icon; wherein displacing a second volume of fluid into the second fluid vessel to transition the second deformable region from the retracted setting to a third setting comprises defining an input button detect selecting the second graphical icon.

13. The method of claim 12, wherein rendering the first graphical icon and the second graphical icon comprises rendering a graphical toggle switch, a first button of the toggle switch corresponding to the first graphical icon, a second button of the toggle switch corresponding to the second graphical icon.

14. The method of claim 11, wherein displacing the second volume of fluid into the second fluid vessel comprises displacing the first volume of fluid from the first fluid vessel into the second fluid vessel to transition the first deformable region from the expanded setting to the retracted setting and substantially simultaneously transition the second deformable region from the retracted setting to expanded setting.

15. The method of claim 11, wherein displacing the first volume of fluid from the first fluid vessel comprises gradually decreasing the first volume of fluid in the first fluid vessel; and wherein displacing a second volume of fluid into the second fluid vessel comprises gradually increasing the second volume of fluid in the second fluid vessel.

16. The method of claim 11, wherein displacing the first volume of fluid from the first fluid vessel comprises retracting the first deformable region by a degree of deformation to the second setting offset above the third region by a first height; and wherein displacing the second volume of fluid into the second vessel comprises expanding the second deformable region to a second height offset above the third region and corresponding to the degree of deformation.

17. The method of claim 11, further comprising detecting a duration of the input; wherein displacing fluid from the first fluid vessel comprises displacing a volume of fluid proportional to the duration of the input; and wherein

displacing fluid into the second vessel comprises displacing the second volume of fluid of a volume proportional to the duration of the input.

18. The method of claim **11**, wherein displacing the first volume of fluid from the first fluid vessel comprises displacing the first volume of fluid of a volume proportional to the magnitude of the change in pressure.

19. The method of claim **11**, wherein displacing the first volume of fluid from the first fluid vessel comprises displacing the first volume of fluid and decreasing pressure in the fluid vessel by a first pressure magnitude; wherein displacing the second volume of fluid into the second fluid vessel comprises displacing the second volume of fluid and increasing pressure in the fluid vessel by a second pressure magnitude proportional to the first pressure magnitude.

20. The method of claim **19**, wherein displacing fluid into the second fluid vessel comprises displacing the second volume of fluid and increasing pressure in the fluid vessel by the second pressure magnitude greater than the first pressure magnitude.

21. The method of claim **11**, wherein displacing the second volume of fluid into the second fluid vessel comprises displacing the second volume of fluid corresponding to a first ratio in response to the second volume of fluid greater than a threshold volume of fluid and corresponding to a second ratio in response to the second volume of fluid less than a threshold volume of fluid.

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